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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

VIA HAND DELIVERY
Marlene H. Dortch, Esquire
Secretary
Federal Communications Commission
445 12th Street, S.W.
Washington, DC 20554

Re: ET Docket No. 02-135
Reply Comments of Cornell University

Dear Ms. Dortch:

Transmitted herewith, on behalf of Cornell University, are an original and four copies of its Reply Comments filed in the above-referenced proceeding.

If questions arise, please contact me.

Sincerely,

Paul Feldman

Paul J. Feldman
Counsel for Cornell University

PJF:jpg

Enclosure

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Before the
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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

In the Matter of	)	
	)	
Spectrum Policy Task Force	)	ET Docket No. 02-135
	)	

REPLY COMMENTS OF CORNELL UNIVERSITY

CORNELL UNIVERSITY

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July 23, 2002

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Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

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REPLY COMMENTS OF CORNELL UNIVERSITY

Cornell University, by its attorney, hereby submits its reply comments in response to the June 2, 2002 Public Notice (the "*Notice*") in the above-captioned proceeding, announcing that the Spectrum Task Force ("STF") seeks comments on a range of issues relevant to spectrum policy. Herein, Cornell shows support in the record for the propositions that 1) passive scientific use of the spectrum has substantial value that cannot be easily measured in economic terms, so that application of market-oriented allocation and assignment policies to such use is inappropriate; 2) passive scientific use of the spectrum is uniquely vulnerable to interference, and protection of such services cannot be based on economic factors; 3) the definition of "harmful interference" should be made more objective by reference to specific international standards; and 4) the Commission should be cautious about the damage posed by an increased noise floor and harmful interference in passive services bands from unbridled growth of unlicensed services.

I. Introduction: The Importance of Radio Astronomy Observations, and the Unique Vulnerability of Passive Services to Interference.

Cornell has a substantial interest in this proceeding, as it operates the Arecibo Observatory ("Arecibo" or "Observatory") in Arecibo, Puerto Rico. Arecibo is part of the National Astronomy and Ionosphere Center ("NAIC"), a national research center operated under a cooperative agreement with the National Science Foundation ("NSF"). The NSF is an independent federal agency whose aim is to promote scientific and engineering progress in the U.S. Additional funding for Arecibo is provided by the National Aeronautics and Space Administration ("NASA").

As the site of the world's largest single-dish radio telescope, Arecibo is recognized as one of the most important centers in the world for research in radio astronomy and planetary radar.[1] Arecibo has been operating since 1963, and in 1997 work was completed on a multi-million dollar upgrade of the facilities, which significantly expanded the range and sensitivity of the observations that could be made, while increasing the shielding around the telescope in an attempt to reduce interference from ground radiation. The telescope now operates up to 10 GHz.

As the Commission has long recognized, radio astronomy is a vitally important tool used by scientists to study our Universe. It was through the use of radio astronomy that

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[1] Arecibo has a long history of being the site where very significant accomplishments in astronomy have occurred, including: the <u>first</u> discovery of planets outside of our own solar system; discovery of the first pulsar in a binary system, leading to important confirmation of Einstein's theory of gravitational waves and a Nobel Prize for two radio astronomers who performed their research at Arecibo (the third Nobel Prize for radio astronomy in its short 50 year history); and discovery of the correct rotation rate of the planet Mercury, as well as the discovery of ice in craters on Mercury's polar regions (and similar investigation of the polar regions of the Earth's Moon).

scientists discovered the first planets outside the solar system, circling a distant pulsar. Measurements of radio spectral line emission have identified and characterized the birth sites of stars in our own Galaxy, and the complex distribution and evolution of galaxies in the Universe. Radio astronomy measurements have discovered ripples in the cosmic microwave background, generated in the early universe, which later formed the stars and galaxies we know today. Observations of supernovas have allowed us to witness the creation and distribution of heavy elements essential to the formation of planets like the Earth, and of life itself.[2]

The emissions that radio astronomers review are extremely weak -- a typical radio telescope receives only about <u>one-trillionth of a watt</u> from even the strongest cosmic source. Because radio astronomy receivers are designed to pick up such remarkably weak signals, observations by radio astronomers are therefore particularly vulnerable to interference from spurious and out-of-band emissions from licensed and unlicensed users of neighboring bands, and those that produce harmonic emissions that fall into the RAS bands.

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[2] While Cornell does not perform Earth Remote Sensing, it notes that the Earth Exploration Satellite Service ("EESS") is another passive scientific user of the spectrum that shares many of the same characteristics of the Radio Astronomy Service ("RAS") for spectrum management purposes. The EESS is a critical and unique resource for monitoring the global atmospheric and surface state. Satellite-based microwave remote sensing represents the only practical method of obtaining uniform-quality atmospheric and surface data encompassing the most remote oceans as well as densely populated areas of the Earth. EESS data has contributed substantially to the study of meteorology, atmospheric chemistry, oceanography and global change. Currently, instruments operating in the EESS bands provide regular and reliable quantitative atmospheric, oceanic, and land measurements to support an extensive variety of scientific, commercial, and government (civil and military) data users. Applications of the data include aviation forecasts, hurricane and severe storm warning and tracking, seasonal and interannual climate forecasts, decadal-scale monitoring of climate variability, medium-range forecasting, studies of the ocean surface and internal structure, as well as many others.

In addition to the gains in scientific knowledge that results from radio astronomy and Earth sensing, Cornell notes that such research spawns technological developments that are of direct and tangible benefit to the public. For example, radio astronomy techniques have contributed significantly to major advances in the following areas:

- computerized tomography ("CAT scans") as well as other technologies for studying and creating images of tissue inside the human body;
- increasing abilities to forecast earthquakes by very-long-baseline interferometric ("VLBI") measurements of fault motions; and
- use of VLBI techniques in the development of wireless telephone geographic location technologies, which can be used in connection with the Commission's "E911" requirements.[3]

Continued development of new critical technologies by passive scientific observers of the spectrum depends on scientists having continued access to interference-free spectrum. More directly, the underlying science undertaken by the observers cannot be performed without access to interference-free spectrum. Loss of such access constitutes a diminution of the scientific and cultural heritage of all people, as well as a reduction in the practical civil and military applications that would be derived from the information learned and the technologies developed.[4]

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3 *See also,* "New Technology Fostered by Radio Astronomy", attached to the Comments of the National Radio Astronomy Observatory ("NRAO") in this proceeding.

4 *See also*, Comments of Prof. Peter Schloerb at page 2, and Comments of Prof. Leo Blitz and Prof. Geoffrey Bower at page 2, noting that the basic research performed by radio astronomers and Earth scientists leads to "spin-off" technologies, attracts students to fields that keep the U.S. in the technological forefront, and answers questions of importance to all people.

II. Market-Oriented Allocation and Assignment Policies

Page 2 of the *Notice* points out that in recent years, the Commission has implemented certain spectrum allocation and assignment policies aimed at insuring that the important resource of spectrum is put to its best and highest value use. Cornell recognizes that such an approach is based on widely accepted theories regarding economic efficiency. Cornell notes, however, that under such theories, the allocation of resources for "public goods" often results in a "market failure" because there are insufficient incentives for private entities to finance such allocations. An example of such a public good is a large area of scenic land which can be enjoyed by all people for its beauty. Analogously, the existence of interference-free spectrum which can be used for scientific research constitutes a public good which benefits all people, but cannot be properly allocated through market-oriented policies. Just as in the case of scenic land, where the common solution to the market failure is the reservation of that land (*e.g.*, as a "park") by the government for limited use so that the public good is preserved, so in the case of spectrum, the Commission must be mindful that interference free spectrum for scientific use must be set aside (*i.e.*, allocated and preserved) by the Commission, outside of market-oriented policies.

Cornell notes that over 20 commentators in this proceeding raised similar points, demonstrating that while use of the spectrum for scientific observation has produced many important economic benefits, the true and full value of scientific use of the spectrum cannot properly be measured using traditional economic mechanisms. *See*, *e.g.*, the Comments of NRAO, Comments of Dr. Thomas B. H. Kuiper,[5] Comments of Professors Leo Blitz and Geoffrey Bower, and Comments of Professor Peter Schloerb. Indeed, at page 1 of his Comments, Dr. Kuiper points out that because it is not possible to forecast the outcome of scientific exploration, it is therefore not possible to estimate the eventual economic value of that exploration. However, recent history has shown the great value of science to society.

Scientific observation is not the only case of possible market failure when it comes to spectrum allocation. The same sort of market failure would apply to the spectrum needs of public safety organizations. *See, e.g.*, Comments of the Association of Public-Safety Communications Officials International ("APCO") at page 3; Comments of United Telecommunications Council at page 3. In all of these cases, a purely economic analysis of the "highest value" of spectrum use ignores important non-economic factors such as public safety, national security, and the progress of scientific knowledge.

III. Interference Protection

The *Notice* presents the observation that radio spectrum is becoming increasingly congested, and that as a result the issue as to what constitutes acceptable interference is becoming increasingly important. The *Notice* then goes on to ask specific questions regarding interference protection, including whether a new definition of "harmful interference" is needed, and whether interference resolution mechanisms should be based on economic rather than technical factors. These matters are discussed below.

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5 Dr. Kuiper made three filings in this proceeding on July 8th. The Comments referenced herein is the only one of those documents that is comprised of three pages.

A. Interference Protection for Passive Scientific Observation Cannot Be Based on Economic Factors

Cornell starts with the proposition that as passive users of the spectrum, using the most sensitive receivers ever built, radio astronomers and Earth Sensing scientists are probably more vulnerable to interference than any other users of the spectrum. Accordingly, protection from harmful interference is critical to such scientific use. Cornell is thus greatly concerned when the *Notice* asks, in Question 16, whether interference resolution should be based on economic factors. Regardless of whether or not such an approach is appropriate in the context of commercial services, it is clearly not appropriate when the entity receiving interference is a passive scientific user, for the reasons set forth in Section II above: the value of such use cannot be fully or fairly measured using purely economic factors. *See, e.g.*, Comments of NRAO at page 4. Furthermore, while the passive scientific community is continually investigating and implementing techniques to reduce the vulnerability of their facilities, such techniques usually require compromises in the performance of the facilities, and thus impair scientific observation. *See, e.g.*, Comments of Prof. Leo Blitz and Prof. Geoffrey Bower at page 3. While such impairment generates measurable costs to the observer (*e.g.*, increased cost of construction, increased time for observation), it also generates costs to society that cannot be measured, but which may be very substantial (*i.e.*, loss of potentially critical scientific data). What would the cost be of interference impeding a scientist from observing phenomena so far back in space and time that the principles resulting in the creation of the Universe are finally elucidated? Cornell does not know how to measure the economic loss in such a case, but the cultural and scientific loss to mankind would certainly be immense.

B. "Harmful Interference" Can Be Specifically Defined Using International Regulations, and Must Not be Modified Otherwise.

The *Notice* asks in Question 7 whether new definitions of "interference" and "harmful interference" are needed. Similarly, in Question 12 the *Notice* asks whether those definitions should change as technology advances. Cornell believes that the definition of "harmful interference" should be made more specific and should be based on appropriate international regulations. Furthermore, while changes in technology may be relevant considerations, the Commission should not change the definitions of such terms unless the internationally accepted definitions are also changed.

Section 2.1 of the Commission's rules defines "Harmful Interference" as interference which "seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with these [international] Radio Regulations." There is no need to change this definition. What is needed, however, is greater use by the Commission of specific standards that define the level of interference in objective, rather than subjective, terms. Such an approach would help minimize disputes as to whether a service is or is not receiving a harmful level of interference.

The Commission's definition of harmful interference specifically references the use of international regulations. As noted in the Comments of Dr. Kuiper at pages 2-3, ITU-R RA.769-1 sets forth, band by band, the levels of interference considered harmful to radio astronomy.[6] While, as he notes, RA.769 is a Recommendation, it is generally treated throughout the world as if it were a Regulation. Cornell urges the Commission to follow

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6 ITU-R SA.1029 sets out similar standards for the EESS.

the requirement of its own definition of harmful interference, and specifically incorporate the internationally accepted standards.

Cornell recognizes, as does the Commission in Question 12, that changes in technology are relevant to an analysis of interference issues. But Cornell suggests that the Commission be cautious in its approach to changing standards on this basis, as growth in technology can be a double-edged sword in this context. While there have been improvements in the methods of protecting passive facilities from interference, at the very same time the sensitivity of these facilities has been improving as well. *See* Comments of Dr. Kuiper at page 2 and Comments of Prof. Leo Blitz and Prof. Geoffrey Bower at pages 3-4. Furthermore, growth in technology of transmitting services can and has led to increased interference to passive observations. Take, for example, satellite services. In November of 1999, the Commission issued a Public Notice on Part 25 satellite out-of-band emission standards, and appeared to suggest that such standards should be loosened, in light of the growth of satellite transmission technology. In response, the National Academies' Committee on Radio Frequencies ("CORF") stated the following in its December 19, 1999 Comments (pages 3-4):

> Twenty-five years of advancing technology have brought a proliferation of spectral usage as well as an associated increase of out-of-band ("OOB") and spurious emissions. While advancing technology has improved the ability of some individual space-borne transmitters to reduce unwanted emissions, the introduction of "broadband and significantly different modulation or frequency-use schemes" have expanded the spectral reach and impact of unwanted emissions. Thus the need to minimize unwanted emissions have correspondingly increased with improved technology, not decreased. Furthermore, the increasing number of satellites in a network, as well as the presence of multiple networks which share the same allocated band, have exacerbated the impact

> of the <u>aggregate</u> unwanted emissions on receivers in the same, adjacent, nearby and harmonically related bands. As a result, more than ever, unwanted emissions, especially from downlinks, detrimentally impact scientific receivers located on the Earth's surface, in the air and in space.... Similarly, the expansion of satellite services to higher frequency bands does not alleviate the concern of passive users of the spectrum, but rather presents an additional threat to the passive services since passive scientific users currently make observations in such bands and will do so increasingly over time.

That statement still holds true.

In sum, the definition of harmful interference need not be changed, but needs only to be fleshed out with objective, observable standards provided by international regulations. Furthermore, it is becoming increasingly important to recognize that the <u>aggregate</u> interference received at a site from multiple operators may be harmful, even if each individual transmission of each individual operator does not reach that level. Lastly, while relevant changes in technology should be noted, the Commission should be cautious in changing the standards used for harmful interference. It should look to whether changes have been made in international standards, before it changes the domestic standards. *See, e.g.,* Comments of NRAO at page 4.

c. <u>Cornell is Concerned About the Danger of Increased Noise Floor and Harmful Interference From Unbridled Growth in Unlicensed Services.</u>

<u>Question 5</u> of the *Notice* asks whether more spectrum should be set aside for unlicensed devices, and a number of commentators have responded affirmatively. Yet passive science commentators, and others, have deep and legitimate concerns about the growth of unlicensed services.

For example, in pages 37 through 40 of its Comments, Cingular Wireless LLC documents the potentially dangerous impact that unbridled growth of unlicensed devices could have on the overall radio noise environment. Therein, Cingular notes that the Commission's own Technological Advisory Counsel ("TAC") has stated that we "could potentially be entering a period of rapid degradation of the noise environment" and that "as we entered the new millennium, new noise sources are being developed (e.g., ultrawideband devices), and other electronic devices continue to proliferate as fast as the technology and the regulatory process will allow. Many of these other individual sources of "noise" may meet the current [FCC] rules, but in great numbers they may negatively affect the overall electromagnetic noise environment."[7] Of greatest concern, however, is the TAC statement that "data on the level and the changes of the noise environment is sorely lacking, however, as neither the FCC nor industry has tracked recent noise growth nor modeled how it will increase in the future."[8] While Cingular, as the operator of the robust and active cellular/PCS service is concerned about the increase in the noise floor created by unlicensed devices, passive users of the spectrum such as radio astronomers must be even more concerned. For example, Professors Blitz and Bower state at page 4 of their Comments that:

> "We note the problematic nature of unlicensed devices for RA. An accumulation of interference from multiple unlicensed

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[7] Comments of Cingular Wireless at pages 37-38, citing FCC Technological Advisory Counsel, Fourth Meeting Report at 23 and Sixth Meeting Report at 25. Cornell's concern regarding an increased noise floor is focused on the impact in bands used by or reserved for passive services.

[8] Comments of Cingular Wireless at page 37, citing TAC Fourth Meeting Report at 23.

> devices would be essentially impossible to remove through interference mitigation techniques. They will effectively form a noise floor below which faint sources can no longer be detected. Single-point sources of interference are substantially easier to mitigate."

Cornell shares this concern. Thus, the Commission should be particularly cautious in evaluating the suggestion such as those of Kevin Werbach to "treat spectrum bands as 'commons,' available to all." Werbach Comments at page 2. While Mr. Werbach acknowledges the well-known "tragedy of the commons" in which as he describes, "if everyone is yelling, any additional speaker will decrease the ability of *everyone* to hear. . ." he suggests a comforting solution that "if everyone in the room whispers, far more simultaneous conversations are possible." Werbach Comments at page 7. However, while Cornell supports the development of low-noise devices, the problem with Mr. Werbach's comforting analogy is that a transmission heard as a "whisper" to traditional receivers is heard as a "shout" by the remarkably sensitive receivers of radio astronomers and earth remote sensing scientists. As noted at page 3 *supra*, a typical radio telescope receives only about one-trillionth of a watt from even the strongest cosmic source. With such sensitivities, transmissions that would be harmless to receivers in other services can be tremendously harmful to passive science observations. Thus, while Cornell is pleased that Mr. Werbach suggests that the Commission consult with entities such as the NTIA and the National Academy of Sciences, Cornell remains particularly concerned regarding his suggestion that "the Commission should not limit itself to frequency bands previously designated for commercial use." Werbach Comments at pages 5-6. Regardless of the impact on bands used for other purposes, it would be particularly dangerous to encourage unbridled unlicensed use in bands allocated in or near bands allocated on a primary (or even secondary) basis to passive scientific observation.

IV. Conclusion: The Need to Preserve the "Park" and Clean the "Windows".

As shown herein and in numerous Comments filed in this proceeding, use of the spectrum for passive scientific observation produces very important intellectual and cultural benefits. In addition, it produces substantial indirect economic benefits through the technologies developed, and through the civil and military applications of data for weather forecasting, analysis of atmospheric and soil data, etc. Nevertheless, use of economic factors in applying spectrum allocation and interference policies to passive uses would be inappropriate due to market failure.

Some comments in this proceeding propose solutions for protection of passive users that are analogous to the protection of national parks.[9] Cornell supports this approach, and notes that it has two elements: set-aside and preservation of particular spectrum bands (primary allocations for passive services), and set-aside and preservation of specific geographic areas surrounding radio astronomy sites (such as the "Quiet Zones" specified in Section 1.924 of the Commission's rules).[10] Such an approach has provided important and necessary protections to the Arecibo Observatory and other radio astronomy sites.

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[9] *See, e.g.,* Comments of Professors Blitz and Bower at page 4.

[10] *See, e.g.,* Comments of Dr. Kuiper at page 1. The Commission has enacted Quiet Zone rules specifically protecting Arecibo, and making Arecibo a Quiet Zone Entity. *See* Section 1.924(d) of the Commission's Rules. *See, also,* Radio Astronomy Coordination Zone in Puerto Rico, Report and Order, 12 FCC Rcd 16522 (1997).

However, Cornell offers one further analogy for the need to protect passive services: windows. Radio astronomy uses a unique and powerful window on the Universe. EESS exploits a unique and powerful window to study phenomena on Earth that are not otherwise observable. These important windows are increasingly being "fogged" by interference from other services. The Commission must restore and preserve the clarity of these windows if the tremendous benefits of radio astronomy and EESS are to continue.

Respectfully submitted,
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July 23, 2002

CERTIFICATE OF SERVICE

I, Joan P. George, a secretary in the law firm of Fletcher, Heald & Hildreth, do hereby certify that a true copy of the *Reply Comments of Cornell University* was sent this 23rd day of July, 2002 by hand where indicated and via United States First Class Mail, postage prepaid, to the following:

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